Modular Rocket Engine Control Software Update

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NASA is conducting studies with the goal of enhancing and furthering the technology base to support high-priority programs. To support the propulsion system activities, basic research and technology must be accomplished in the engine control and health monitoring arena. To accommodate evolving technologies this system must be modular to allow interface redesign as the system requirements change. Modular rocket engine control software (MRECS), which is being developed by Lockheed Martin Space Information Systems, is a research and technology effort whose primary purpose is to demonstrate software development and maintenance cost reduction by implementing a modular, flexible software architecture.

Approximately 35 people are presently working full time to support the development, verification, and validation of the Space Shuttle Main Engine (SSME) controller software. A significant percentage of the time and manpower required for this effort is the verification and validation of SSME software. Software logic changes, resulting from flight requirement changes and/or software logic corrections plus the need for special test software, have occurred at a relatively high frequency, each new software version requiring verification and validation. Sixteen software versions have been flown on 53 Space Shuttle missions since return to flight in 1988, an average of one new software version every 3.3 flights.

The purpose of the MRECS contract is to determine and develop an approach to modular rocket engine control software that will allow the incorporation of new system requirements and technology developments in sensors, actuators, input/output, connectors, and health/safety monitoring techniques with fewer software specialists, thus reducing costs. The modular software concept creates a “fire wall” between modules so that when code is changed, only the affected module needs to be reverified. Some of the logic errors discovered in the current SSME software might not have occurred with more compartmentalized software.

The Marshall Avionics System Test-bed (MAST) is being used to develop the MRECS software and for demonstrations of this software at key milestone events. The MRECS engine controller system was installed in the MAST laboratory for verification of the software. A demonstration of a sensor input task was performed in June 1995, with a proof-of-concept demonstration, including an engine health management task, held in September 1995.

The tasks planned for 1996 and 1997 were postponed so that MRECS could be used to support the firing of an SSME with a controller that uses a commercial off-the-shelf computer, operating in a predominately simplex mode. Lockheed Martin is developing the software using requirements derived from the SSME controller software requirements, as furnished them by MSFC. The test firing, which is known as PC Quickfire 2, is planned at Stennis Space Center in January 1997. This is the second of four planned testing phases. Phase 1 used a laptop computer and was conducted in February 1996. MRECS was not used on that test. Phases 3 and 4 are planned to follow and would consist of SSME tests with fully redundant and flight-worthy controllers, respectively. These would be further steps in the evolution of MRECS toward future space applications. No commitment to these phases has been made at this time, however.

MRECS will also be used to support a test firing in January 1998, of a low-cost booster technology propulsion test article. Requirements for this test are being written by MSFC. MSFC and Lockheed Martin will develop the software, starting with the existing modular design.

Modular main propulsion system software has been identified as a task item in the Reusable Launch Vehicle Long-Term/High-Payoff Technologies Program. Preliminary results from the MRECS contract indicate that it is the proper approach for future flight software. The testing currently planned should serve as further validation of this approach. The reduction in time and manpower required for the verification and validation of software should result in significant cost savings.

Sponsor: Office of Aeronautics

Industry Involvement: Lockheed Martin Space Information Systems

Biographical Sketch: Richard Beckham is a computer engineer in the Astrionics Laboratory at MSFC. His primary duty is the coordination and evaluation of requirements, development, testing, and flight support for the Space Shuttle Main Engine controller software. Since March 1995, he has been the contracting officer’s technical representative for the Modular Rocket Engine Control Software contract. He holds bachelor of science and master of science degrees in electrical engineering from The University of Tennessee.